Bahrain Medical Bulletin, Vol. 37, No. 2, June 2015

Bomb-Blast Victim with Traumatic Ischemic Injury Treated with Hyperbaric Oxygen

Adel Abdulaal, MD, BScMedHons, MScMedSc, FCHM (SA), DMO* Jason Paul D. Hermosilla, MD, BSc (Bio)** Hiske Smart, RN, MA Nursing, BSocSc, PG Dip, IIWCC***

A case of a 25-year-old male suffered from a blast injury to the left thigh, Gustilo Grade IIIC. Repair of the upper femoral vessels and the muscles was performed; in addition, an application of the external fixators to the comminuted fracture of the left femur was achieved. The patient was able to be mobile with the help of a walker in 8 weeks instead of ending with amputation.

Acute crush injuries and acute traumatic ischemias are indications for hyperbaric oxygen treatment to maximize perfusion and save damaged tissue. Timely multidisciplinary approach is essential in managing blast injuries.

---

* Head of Department
** Senior House Officer
*** Clinical Nurse Specialist
Hyperbaric and Diving Medicine Department
King Hamad University of Bahrain
Kingdom of Bahrain
Email: adel.abdulaal@khuh.org.bh

Blast injuries are expanding beyond the scope of military field. Most studies are found in military hospitals in Afghanistan and Iraq where civil unrest and acts of terrorism are more common[1]. Though these cases are highly variable in different regions of the world, the medical community should be very acquainted with the course of management.

The complications of blast injuries vary with the type of explosive. Factors that need consideration in the management of blast injuries include the type of explosive and setting. High order explosives (HE), which are almost exclusively used in the military and occasionally in industrial settings, cause different injury patterns from low order explosives (LE). The environment and other situational factors such as the position of the victim, distance from the explosive, whether the blast took place in an enclosed or open space result into different clinical scenarios[2,3].

Political unrest all over the world has gone beyond the use of Molotov cocktails and arson. The use of improvised explosive devices (IEDs) is starting to complicate and add another dimension to the clinical management of cases clinicians have to deal with[4].

The nature of blast injuries tends to present a complex set of clinical challenges that would demand aggressive and timely intervention of different medical and surgical disciplines[5]. Multiple medical disciplines need to be involved to ensure appropriate and timely intervention since blast pathophysiology involves multiple organ systems including ophthalmology,

gastrointestinal and pulmonary systems[1-6].

The aim of this report is to present a case of blast victim with multiple injuries which were managed by multiple disciplines and hyperbaric oxygen.

THE CASE

A twenty-five-year-old male presented with a large gaping wound 20x15 cm at the anterior aspect of the left mid-thigh, which was bleeding profusely with a gross deformity indicative of an underlying femoral fracture, see figure 1. The patient was seen near an explosive device that was detonated near a car 4 meters away from the victim. The patient was conscious and coherent but in respiratory distress. Distal to the wound, the dorsal pedis artery, posterior tibial artery, popliteal artery and the peroneal artery were not palpable. An immediate vascular repair of the superficial femoral artery was performed. Muscle repair and application of external fixators were performed for the femoral fracture. Pulses were re-established and remained triphasic in the posterior tibial and dorsalis pedis arteries, confirmed by handheld Doppler. The patient was started on Heparin. An ultrasound guided peritoneal lavage was performed and was unremarkable. The patient was managed in the ICU post-operatively and was intubated with inotropic support.

Figure 1: The Patient in the Operating Room within 4 hours of the Blast Injury

The patient was referred to the Hyperbaric Oxygen therapy 24 hours after admission to ICU. He was fully ventilated with the Intensive Care Team. Hyperbaric Oxygen therapy commenced at 2.5 ATA for 90 minutes, see figure 2. The patient developed a TEED 4 barotrauma in the right ear which was treated with a myringotomy.

Figure 2: HBOT Chamber Session Day 1

The patient continued to be treated with Hyperbaric Oxygen at 2.0 ATA. He was eventually weaned and extubated on day 4 with good oxygen saturation. Because the patient developed compartment syndrome, lateral fasciotomies were performed bilaterally in the calf region. Wound cultures were initiated and antibiotic management was adjusted accordingly.

The patient continued to receive HBOT, physiotherapy and debridement anterior to the lateral fasciotomy, see figure 3 and 4. At the end of the second week, the patient was comfortable with Topical Negative Pressure Therapy (TNPT).

Figure 3: Dressing Performed with Sutures Removal One Day after TNPT was Installed

Figure 4: Fasciotomy Site- Lateral Calf Left Leg

On the third week, the patient was still in intensive care with stable vital signs. On the third week, external fixators were removed and an intramedullary pin was placed, see figure 5. Physiotherapy was continued after the operation as well as HBOT (2.5 ATA for 90 minutes).

Figure 5: X-Ray Femur Left Intramedullary Pin in Place

On the fifth week, the patient had a skin graft on the fasciotomy sites. The patient continued to receive HBOT. All the grafts took well without complications.

The patient continued to receive wound dressing until the eight week postoperatively. The patient had extensive physiotherapy sessions with breathing exercises, ankle pumping, static quadriceps exercises, straight leg exercises, Theraband^{TM} exercises for quadriceps and hamstrings, short arc knee exercises, reverse technique and sit to stand to the walking frame. The patient was allowed to ambulate with the walking frame for 7 meters, see figures 6 and 7.

Figure 6: Forty-Degree Leg Raise after Skin Grafting and Physiotherapy

Figure 7: Patient on a Walking-frame Week 8

DISCUSSION

There are four types of blast injuries: primary, secondary, tertiary and quaternary. Current evidence in blast injuries shows that the lack of tympanic barotrauma during the incident will rule out the absence of a blast lung as a result of the initial blast wave[2,3]. The occurrence of the incident in an open space was to the victim's advantage, since a similar blast occurring in an enclosed space might prove fatal[2,4-6].

Secondary blast injuries are the result of highly energized projectiles/debris propagated by the blast wind and would depend on the design of the IED[2-5]. Secondary blast injuries were evident in this patient probably because this was a homemade bomb. Although the exact event could not be adequately described by the victim, there was strong evidence that this was a result of high-energy transfer via an unknown projectile to the medial leg area causing surrounding soft tissue

injury and a comminuted fracture rather than an injury caused directly by the primary blast wind.

Tertiary blast injuries are brought about by the displacement of the patient by the blast wind while quaternary blast injuries are brought about by the environment (e.g. falling debris); both were not observed in the patient[3,4,5].

The value of HBOT in blast injuries is as multifaceted as the nature of the complications of blast injuries themselves. According to Gustilo Anderson Classification, the patient would be IIIC with the presence of an open fracture and associated vascular injury[7].

Kumar et al showed that out of 61 injured lower limbs, 11 (18.03%) limbs were amputated, 43 (70.5%) salvaged limbs had good function, 4 (6.56%) salvaged limbs had poor function and 3 (4.9%) attempted salvaged limbs were lost to follow-up[9].

Johansen et al proposed the Mangled Extremity Scoring System (MESS) classification based on four clinical criteria: skeletal/soft tissue injury, limb ischemia, shock and age[10].

Slauterbeck et al conducted a study on 37 patients having 43 mangled upper extremities. All nine extremity injuries with a MESS score of equal to or more than 7 were amputated and 34 with a MESS of less than 7 were salvaged[11]. They concluded that the MESS was an early and accurate predictor for identifying the extremities that may be treated by amputation.

The MESS score would classify our patient as a nine where a score more than seven predicts a low likelihood of limb/extremity viability or would necessitate amputation[8].

Russell et al proposed a Limb Salvage Index (LSI) scoring system, based on the analysis of 70 lower extremity injuries involving multiple systems[12]. LSI score of less than 6 predicts successful limb salvage whereas LSI score of 6 or more than six predicts amputations.

O'Sullivan et al retrospectively applied MESS and LSI to 54 extremities in 50 patients of Gustilo Type IIIB and Type IIIC tibial fractures and observed that MESS was more accurate than LSI in predicting limb salvage[13].

The overall prognostication from these different amputation risk scores vary and has been subject to scrutiny over the last few years and on average has a range of 70% to as high as 99% sensitivity and specificity. All of these suggesting a general direction towards performing limb amputations[6,8-13].

A summary of scores for our patient would be MESS 9, LSI 7 and Gustilo Anderson IIIC.

Every appropriate effort should be made to preserve functional and anatomic integrity[1,10,11]. For some severe lower extremity injuries, an amputation and prosthesis may be more effective for the patient than a limb that is still attached but of limited use.

Current recommendations would be to provide 2.0 to 2.4 ATA within 6 hours of injury, ideally three times in a 24-hour period for two days followed by twice for two days and then daily for

two days. Confounding variables such as osteomyelitis, compartment syndrome should be considered in the Hyperbaric Oxygen Treatment management protocols. Complications may warrant extension of the treatment from 15 sessions to as much as 40 in the presence of acute osteomyelitis[15,16].

CONCLUSION

Our patient would be classified to have irreversible limb loss; despite that, he has managed to have a functional limb in 8 weeks. Timely interventions of a multidisciplinary team and HBO played a major role in the limb salvage and reduced morbidity.

In the management of crush injuries and acute ischemic traumas, HBOT should be considered as part of the new protocol.

Author Contribution: All authors share equal effort contribution towards (1) substantial contribution to conception and design, acquisition, analysis and interpretation of data; (2) drafting the article and revising it critically for important intellectual content; and (3) final approval of manuscript version to be published. Yes.

Potential Conflicts of Interest: None.

Competing Interest: None. **Sponsorship**: None.

Submission Date: 8 February 2015. **Acceptance Date:** 28 March 2015.

Ethical Approval: Approved by the Research and Ethical committee, King Hamad University Hospital, Bahrain.

REFERENCES

1. Ramasamy A, Hill AM, Masouros S, et al. Outcomes of IED Foot and Ankle Blast Injuries. J Bone Joint Surg Am 2013; 95(5):e25.
2. Ciraulo DL. Weapons of Mass Destruction. In: Feliciano DV; Mattox KL, Moore EE, eds. Trauma. 6th ed. USA: McGraw-Hill, 2008: 1140-1142.
3. Garner J, Brett SJ. FRCA Mechanisms of Injury by Explosive Devices. Anesthesiol Clin 2007; 25(1):147-60.
4. Gill P, Horgan J, Lovelace J. Improvised Explosive Device: The Problem of Definition, Studies in Conflict & Terrorism. Taylor & Francis Group 2011; 34:9, 732-748.
5. Lemonick D M, Bombings and Blast Injuries: A Primer for Physicians Am. J. Clin Med 2011; 8(3): 134-140.
6. Buettner MF, Wolkenhauer D. Hyperbaric Oxygen Therapy in the Treatment of Open Fractures and Crush Injuries. Emerg Med Clin North Am 2007; 25(1):177-88.
7. Gustilo RB, Anderson JT. Prevention of Infection in the Treatment of One Thousand and Twenty-Five Open Fractures of Long Bones: Retrospective and Prospective Analyses. J Bone Joint Surg Am 1976; 58(4):453-8.

8. Fodor L, Sobec R, Sita-Alb L, et al. Mangled Lower Extremity: Can we Trust the Amputation Scores? Int J Burns Trauma 2012; 2(1):51-8.
9. Kumar MK, Badole C, Patond K. Salvage versus amputation: Utility of Mangled Extremity Severity Score in Severely Injured Lower Limbs. Indian J Orthop 2007; 41(3):183-7.
10. Johansen K, Daines M, Howey T, et al. Objective Criteria Accurately Predict Amputation Following Lower Extremity Trauma. J Trauma 1990; 30(5):568-72; discussion 572-3.
11. Slauterbeck JR, Britton C, Moneim MS, et al. Mangled Extremity Severity Score: An Accurate Guide to Treatment of the Severely Injured Upper Extremity. J Orthop Trauma 1994; 8(4):282-5.
12. Russell WL, Sailors DM, Whittle TB, et al. Burns Annals of Surgery. 1991; 213(5): 473-481.
13. O'Sullivan ST, O'Sullivan M, Pasha N, et al. Is it Possible to Predict Limb Viability in Complex Gustilo IIIB and IIIC Tibial Fractures? A Comparison of Two Predictive Indices. Injury 1997; 28(9-10):639-42.
14. Jagodzinski NA, Weerasinghe C, Porter K. Crush Injuries and Crush Syndrome- a review Part 2: The Local Injury, Trauma 2010; 12:133-148.
15. Strauss MB, Miller SS. The Role of Hyperbaric Oxygen in Crush Injury, Skeletal Muscle-Compartment Syndrome and other Acute Traumatic Ischemias. In: Kindwall EP, Whelan HT, eds. Hyperbaric Medicine Practice 3rd Ed. USA: Best Publishing Company, 2008: 799-828.
16. Strauss MB, Garcia-Covarrubias L, Crush Injuries: Justification of and Indications for Hyperbaric Oxygen Therapy In: Neumann TS, Thom SR, Physiology and Medicine of Hyperbaric Oxygen Therapy 1st ed. USA: Elsevier, 2008: 427-449.